DOCUMENT RESUME

ED 252 392 SE 045 311

AUTHOR Biddulph, Fred; Roger, Juliet
TITLE Exploring an Alternative Science Teaching Approach. Learning in Science Project (Primary). Working Paper No. 109.
INSTITUTION Waikato Univ., Hamilton (New Zealand). Science Education Research Unit.
PUB DATE Feb 83
NOTE 29p.; For related document, see SE 045 303.
PUB TYPE Reports - Evaluative/Feasibility (142)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Comprehension; Concept Formation; *Curriculum Development; Elementary Education; *Elementary School Science; Foreign Countries; Instructional Innovation; Learning Strategies; *Questioning Techniques; Science Curriculum; Science Education; *Science Instruction; Science Projects; *Teaching Methods
IDENTIFIERS *Learning in Science Project (Primary); *New Zealand; Questions; Science Education Research

ABSTRACT

An alternative teaching model has been proposed by the Learning in Science Project (Primary)--LISP(P). The model uses a six-step approach (outlined in an appendix) which fosters an environment in which children can ask questions about a situation, offer explanations, carry out investigations, and report their findings. This paper reports on the experiences of a first-year teacher and her 29 students using the alternative approach during 12 lessons on seeds (each consisting of approximately 30-45 minutes) spread out over 5 weeks. Data were obtained by observing and audiotaping classroom interactions and through observations of and discussions with children during the first three lessons. Analyses of the lessons are presented, followed by a discussion of: features of the children's questions; features of their discussions, explanations, and ideas; and their responses to the alternative teaching approach. The teacher's initial thoughts and feelings about the approach and the perceived difficulties and advantages of the approach are also discussed. The advantages include fostering positive attitudes toward science and providing insight into children's ideas and views of the world about them. In addition, information is provided on what children regard as important and interesting about seeds and on their prior knowledge of the topic. (JN)

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LEARNING IN SCIENCE PROJECT (PRIMARY)

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EXPLORING AN ALTERNATIVE SCIENCE TEACHING APPROACH

Science Education Research Unit
University of Waikato
Hamilton, N.Z.

SE 045 311

Working Paper No. 109

EXPLORING AN ALTERNATIVE SCIENCE TEACHING APPROACH

Fred Biddulph & Juliet Roger[1]

February 1983

A Working Paper of the Learning in Science Project (Primary)

1. Teacher, Glenview Primary School, Hamilton

INTRODUCTION

It is one thing for researchers to use the alternative science teaching approach (Biddulph & Osborne, 1982) to gather data on children's questions and explanations; it is quite another for a class teacher to use the proposed approach (see Appendix 1) as the basis for a series of science lessons on a particular topic. This paper reports on the experiences of one teacher and her children when the alternative science teaching approach was used. The teacher was a first-year teacher with an interest in science, and the class was a Standard 3 mixed-ability class containing 29 children in a city school. The lessons based on the alternative approach were spread over five school weeks.

Information was obtained through participant observation as class teacher by one of us (J.R.), through observation and informal discussions with children in the classroom during the first three lessons by the other author (F.B.), and through an analysis of both the records of the children's initial questions and explanations and the transcripts of audio-tapes made of six group and three class discussions during the first three lessons.

THE LESSONS

1. Amount of support offered to the teacher

Since this was the first time that full use was being made of the alternative science teaching approach, and since no information about children's questions and explanations on 'seeds' (the topic chosen for the lessons) was available, the amount of support that could be offered the teacher was minimal. Support, in fact, was limited to,

(a) the teacher having seen the researcher using the first two stages of the alternative teaching approach with a different class and topic some weeks previously,

(b) providing the teacher with an outline of the alternative science teaching approach,

(c) brief discussion between the researcher and the teacher prior to lessons one and two which provided the teacher with an opportunity to clarify whether or not her planning was consistent with the proposed teaching approach.

2. Topic and sequence of lessons

The children chose the topic 'seeds' from a list of twenty topics suggested by themselves at the invitation of the teacher. This means of selecting a topic based on the children's stated interests was the teacher's idea entirely, and occurred a week or so before the first lesson on the topic. The lessons, of approximately 30-45 minutes, as they were planned by the teacher and as they developed, were as follows:

LESSON 1

(a) The teacher showed the children a variety of seeds and the children were invited to comment on these. Comments were often directed towards identifying the seeds.
(b) The teacher asked the children if they had any questions about seeds, and she recorded these on the board (see Appendix 2).
(c) The teacher then asked the children to form groups, which they did, and she asked each group to choose a question that interested them from the list of 31 questions recorded on the board. She also asked them to write what they thought the answer(s) might be to that question. When they had finished writing, the teacher collected the question and answer papers (see Appendix 3) from each group.
(d) The lesson concluded with the children telling their teacher what they thought of the alternative approach to learning science.

LESSON 2

(a) This lesson was a little shorter than the first lesson and was mostly devoted to the children discussing their research proposals with fellow group members and their teacher, and writing these out.
(b) The lesson concluded in a manner similar to the first lesson with a teacher-directed discussion in which the children reported on their research proposals.

LESSON 3

(a) During this lesson the children completed details of their research proposals, had them approved by the teacher, and began their

investigations. A feature of the lesson was the use made by the children of a biologist who had been invited to the lesson to act as a resource person.

(b) Again the lesson concluded with a teacher-directed class discussion during which the children reported on what they had found out as a result of their investigations. The children also took the opportunity at this time to ask the resource biologist a number of questions that apparently interested them (see Appendix 4).

LESSONS 4-7

Lessons 4-7 involved the children in their own investigations. In general each comprised three flexible stages. The first stage consisted of a brief discussion period during which the children shared any problems, discoveries or questions related to their investigations of the previous lesson. Ideas and suggested ways of improving each group's investigations were offered by both the children and the teacher. This period proved to be valuable in that it focussed the children's attention on their investigations again and clarified exactly what had to be done during each particular lesson. This first stage lasted approximately 5-10 minutes.

The groups then dispersed to carry out their investigations. At this stage the teacher was available as a resource person. An effort was made by the teacher to see every group each day in order to direct and guide the investigations, and also to ensure that good group dynamics were still operating. The investigations themselves were many and varied and incorporated a wide range of skills. This stage varied in duration but usually lasted upwards of forty minutes.

The last stage of each lesson was a sharing time during which the children reported back to the class on their findings for the day. This stage differed from the initial stage in that it was concerned primarily with what the children had actually learnt about seeds in the scientific sense. It was oriented towards extracting the scientific ideas which were emerging from each group's investigations and the teacher took the opportunity to expand on and clarify these ideas.

LESSONS 8 & 9

Lessons 8 and 9 mainly consisted of the children organising their findings into a form which could be presented to the class. They also devised a list of criteria upon which the presentations should be judged. These criteria consisted of such things as the extent to which the group had answered their question, the clarity with which information was presented and the interest value of the presentation.

LESSONS 10 & 11

These lessons comprised the presentation of each group's investigations. Methods of presentation were flexible. Most groups chose to present their work in a chart or project form, but one group chose a tape presentation and another used O.H.P. transparencies.

LESSON 12

The final lesson on seeds was an evaluation of the approach. The children were given an opportunity to say what they thought of the new method of learning. The form of the children's responses was directed to a certain extent by teacher-posed questions about the approach, namely, what they had learnt, how they had enjoyed the study, how the approach could be improved. A free writing time was given at the end whereby the children could add any other impressions of, and reactions to, the approach.

RESPONSES OF THE CHILDREN TO THE ALTERNATIVE SCIENCE TEACHING APPROACH

The children responded enthusiastically to the alternative approach by asking questions, offering explanations, carrying out investigations and reporting on their findings.

1. Features of the children's questions

(a) The children asked many questions:

In contrast to the usual paucity of questions asked by children in the course of lessons (Biddulph, 1982b; Biddulph & Osborne, 1982; Friedrich, 1982; Rowe, 1973) the observer recorded 55 questions asked by the children during the first three lessons of the study of 'seeds'. This was obviously far from the total number of questions asked by the children during the three lessons as the observer could record relatively few of the children's discussions during the time that they worked in groups.

(b) A variety of questions was asked initially:

The 31 questions generated by the children during the first lesson in response to the teacher's invitation related to various aspects of seeds. The questions can be classified as in Table 1.

TABLE 1: Categories of questions asked by the children about 'seeds'.

Type of question	No. of questions	Example of question
'Beyond' seeds	7	What is the biggest tree in the world?
Structure of seeds	7	Why are they all in different shapes?
Growth of seeds	4	Why do seeds grow?
Origin of seeds	4	How are seeds made?
Fate of seeds	3	How do seeds die?
Function of seeds	3	Why are seeds on trees?
Mobility of seeds	2	How do seeds travel?
Cost of seeds	1	Why do seeds cost money?

It is interesting to note that six of the seven questions asked by the children that went beyond 'seeds' related to 'trees'. The children seemed to be using associated experiences or knowledge as a basis for generating questions in these cases. A similar tendency on the part of children was reported by Symington, Osborne, Biddulph and Freyberg (1982) when children asked some questions about 'trees' during a lesson on 'wood'.

Of the remaining 24 questions asked by the children, 18 referred to aspects of seeds which went beyond the children's immediate observation of the selection of seeds presented by their teacher, for example,

"Which came first, the seed or the tree?" and

"Will trees and seeds ever run out?"

Some of these questions seem to have been dependent on the children's past experiences with seeds, for example,

"Why are some seeds poisonous?" and

"Why do seeds cost money?"

Baker (1969) has also noted how the kinds of questions asked by children are not necessarily determined by their immediate situation.

(c) The children chose to investigate only a few of the questions:

Of the 31 questions asked by the children, and one question asked by the observer, at the beginning of lesson one, the children in their groups chose to investigate only five (and one of these was the extra question asked by the observer). The questions chosen, and the number of children who investigated them, are shown in Table 2.

TABLE 2: Questions which children selected for investigation.

Question	No. of groups	No. of children
Will seeds ever grow on the moon?	4	12
Do animals have seeds inside them?	2	7
What does a seed contain?	1	4
Will there ever be a money tree?	1	4
Will trees and seeds ever run out?	1	2
	9	29

It can be seen from Table 2 that approximately two-thirds of the children chose to investigate just two questions, and that one of the other questions investigated by four children related to a tree rather than seeds. Just why the children found these the most interesting questions was not investigated. In future research, however, it would seem to be a worthwhile aspect to explore to gain greater understanding of the children's thinking.

(d) The children asked procedural questions in addition to knowledge-seeking questions:

In addition to the 21 questions asked by the children after the initial question-generating session, a further 24 questions asked by them related to what might be termed procedural matters. Table 3 below shows the type of group in which the knowledge-seeking and procedural questions were asked.

TABLE 3: Number of procedural and knowledge questions asked by the children.

Type of Group	No. of procedural questions	No. of knowledge questions
Small discussion groups	13	7
Whole class groups	11	14
	24	21

Examples of procedural questions asked by children in their small groups were:

"What else could we write?" and

"How do you write that?"

and examples of procedural questions asked by children of the teacher in the class group were:

"Would I be able to ask the scientist something about seeds?" and

"Would we be able to go exploring?"

It is interesting to note how, during the teacher-directed class discussion at the end of the second lesson, the children asked a number of similar questions, apparently to clarify a procedure in their own minds. For example, three questions (not consecutive) related to communicating with a scientist.

"If we wanted to ask a scientist or something, would we be able to do that?"

"If we get really good at it, will we be able to go on a trip to see a scientist?"

"If we know a scientist, would we be able to write to him?"

Similarly, two consecutive questions related to communicating with other people.

"Could you go and ask, you know, people around your home and that if they think animals have seeds inside them?"

"When we go exploring, if we see some people, will we be able to ask them if they know?"

With each of the above questions the teacher replied in the affirmative.

Examples of knowledge-seeking questions asked by the children in their small groups were:

"Does it rain up on the moon though?" and

"What will happen, because there's no gravity?"

The fourteen knowledge-seeking questions (see Appendix 4) asked by the children in the class group situation at the end of lesson three were all directed to the resource biologist. Several important features of these questions seem worth mentioning. Firstly, four of the questions (No. 9, 10, 11, 13) are the same questions as the children asked initially in lesson one, but which were not chosen by any group to investigate. One of the questions, in fact, was identically worded.

"Which came first, the seed or the tree?"

Whether or not the questions were reasked by the children who originally asked them is not known but it appears that they continued to hold strong interest for some of the children. Another of the questions (No. 13) had something added in the reasking. In its original form the question was,

"Why are seeds hard?"

When it was asked the second time it read,

"Why are seeds so hard? Is it just to protect theirselves?"

This illustrates a second feature of these questions, namely that many of them are relatively elaborate compared with the original question and, in addition, a number contain possible explanations within them. One child, for example, in asking a question about the skin on a seed, had some ideas as to why the seed was encased in a thick skin.

> "If a seed's got a really thick skin on it, is that because a lot of animals like to eat it, or is it just so when it drops onto the ground it'll be ...?"

Bearing in mind the restricted nature of children's questions in primary science classes (Biddulph, 1982b) it would seem that the alternative teaching approach used by the teacher in this series of lessons was, in some way, both enabling the children to think in greater depth and

encouraging them to express their thoughts. In future research it may be of value to explore the communication and interaction processes more fully.

Another feature of the later questions is that the majority go beyond the original questions asked. For example, during lesson one no child asked whether it would be possible to see a seed grow, but by the end of the third lesson a girl asked just that.

> "If you had a seed and you put it in water, and you kept watching it and watching it all day and night, could you actually see it grow up, and make it grow, see it grow?"

It seems that the interim experiences of the children enabled some of them to generate new questions.

A fourth feature of the questions is similar to that of the procedural questions asked of the class teacher, that is, questions were being asked by the children apparently to enable them to clarify an idea, or to resolve a seeming contradiction. One child, for example, was apparently puzzled as to how the embryo plant could emerge from a thickly-cased seed and asked,

> "If a seed has a thick layer on top of it so nothing can get into it, how would the seed kind of burst out?"

Another example occurred when the resource biologist used the word 'embryo' in one explanation and mentioned that it was the 'tiny wee plant' inside a seed. One girl immediately sought further clarification by asking,

> "Is the embryo seed the sort of part of it?"

The procedural questions asked of the teacher and the knowledge questions asked of the resource biologist suggest that by the end of lessons two and three a number of children, at least, were not only articulating themselves in a relatively sophisticated manner but were also genuinely interested in investigating certain questions and making sense of certain issues relating to 'seeds' (and, in some cases, 'trees').

2. Features of the children's discussions, explanations and ideas

An analysis of the children's questions and explanations, together with an analysis of the transcripts of their discussions, revealed a number of

features in the children's communications moves, in their investigatory strategies and in their thinking.

(a) The children interacted meaningfully during small group discussions:

It seemed that the interaction among the children during the times when they worked together in small groups was meaningful in the sense that it was both purposeful and interdependent. Most of the children's discussion focussed on the set tasks, which emanated from the children's own questions, rather than on quite unrelated matters. The following is part of the discussion among a group of four children concerning the explanation they were going to suggest about whether or not seeds could ever be grown on the moon, and shows the purposeful and sustained on-task nature of the discussion.

1st boy: Could be possible if you get a glass case and put oxygen in it.

1st girl: It would have to be airtight though.

1st boy: Yeah.

2nd girl: No (rest of statement is unclear).

2nd boy: Probably die of cold.

2nd girl: Yeah, no, what would happen because there's no gravity?

1st girl: I know (rest of statement also unclear).

2nd boy: The flowers would fly away.

1st boy: Just float away.

2nd girl: I know, and even a brick just floats up.

1st girl: Why don't they, um.

1st boy: A ten ton weight doesn't.

2nd girl: Um, it's, oh what was the

2nd boy: (telling recorder what to write) It might be possible but that will be incredible.

A little later when the children were still talking about seed planting and the problems of gravity, one child apparently felt that they were drifting too far from the task and recalled them to it.

1st boy: Drop a seed in a crater.

1st girl: Yeah.

2nd girl: Yeah, you could actually.

2nd boy: But it would just go 'boing'!

2nd girl: No, it wouldn't even go down. You'd have to

1st boy: You'd just have to go

1st girl: We have to talk about the question and not about space.

Not only were the children pursuing their task in a purposeful way but they also seemed to be taking their cues from each other. This is further illustrated by the conversation of several children in a different group who were considering how they could check whether or not their explanation was a good one. One boy had just suggested leaving one seed in the darkness and another in the light, both without water.

1st girl: I've tried that experiment.

1st boy: What happened?

2nd boy: Did it turn out?

1st girl: No, the one in the dark cupboard died, but the one in the light lived.

1st boy: No, but it's got no water.

This taking of cues from each other occurred even on the few occasions when the discussion did drift away from the set task, as the following conversation shows.

1st girl: (speaking to one boy in the group) You'll be ten today. I forgot about that.

1st boy: Yep.

2nd girl: Is he?

1st boy & 1st girl: (together) Yep, yeah.

Usually the children elaborated their ideas in response to the comments of others in the discussion situations but some were also prepared to state a contrary view. An example is the statement of the child who said that a seed wouldn't even go down a moon crater. Another example is contained in the coversation of two children who were trying to identify silver birch tree seeds. The boy thought that the 'catkin' contained one seed somewhere in the middle but the girl disagreed and said that there was a seed in each of the many paper-thin discs.

Boy: It's in the um, the seed, it's kind of a little case. It's kind of a round case and in the very centre there's a little seed.

Girl: No, these bits here (thin seed discs) have got a seed contained in the middle of them.

(b) Sometimes children acted on their assertions as if they were fact:

The extent to which the children really believed in some of the things that they said was not explored, but on some occasions it seemed that they believed in their assertions and used them as a basis for further discussion. The assertion by one child that there is no gravity on the moon and the conversation that followed is an example. Another instance was when a boy in another group told the observer that he didn't think seeds would grow on the moon and the observer asked if he had checked to see if it was a good answer. The boy replied,

> "No... but I don't think seeds can grow on the moon because when men go on the moon they need heavier stuff, and seeds are light and they would just float away."

Apparently the boy saw no need to check on such an 'obvious' thing. A further example was that of another two boys who had decided to place their jar with seed in a cold place because that is 'what it's like on the moon'. They described their experiment to the observer,

> 1st boy: Get a jar, cover it in black paper, get a seed, put it in dirt, put a top on it, give it no oxygen and put it in a cold place so it
>
> 2nd boy: Like, there is no sun; that's kind of what it's like on the moon. We want to see if it will grow.

van Aalst (1980) mentions this type of thinking in children. To children, natural or commonsense knowledge is self-evident. Piaget (1977) has also described how children tend to believe without proof. Children seem to believe that the whole world thinks as they do and they therefore state their views without proof as they feel no need to convince others. Other examples of children's discussions cited later in this paper, such as the explanation by one boy of why there is no rain on the moon, show that some of the children in some situations do offer proof.

(c) A group written-statement did not necessarily reflect all the major points raised during discussion:

An earlier paper (Biddulph, 1982b) described how the spokesperson for a group did not necessarily report the group view. A similar thing

occurred with one of the groups observed during the first lesson, except that on this occasion the report was in written form and did reflect the group view but to a limited extent. In answer to the question, "Will seeds ever grow on the moon?" the recorder had written,

> "It might be possible that a plant could live on the moon but I don't think so. If a plant went on the moon I think it would die from the coldness and it would die from oxygen."

Apart from the fact that he meant 'lack of oxygen' other important points raised in their discussion which were not incorporated into their statement were:

* it might be possible to grow them in a glasshouse with oxygen;
* scientists could grow them because they have all the gear and chemicals;
* it would not be possible because there is no gravity on the moon and things just float away.

Why the children's statement included only some of their discussion points was not investigated, but the observation suggests that the written explanations of the children may not accurately reflect their discussions, or may fail to take important aspects of their discussions into account. It seems to be an aspect that requires further investigation.

(d) Children suggested a variety of investigatory strategies:

In a previous paper (Biddulph and Osborne, 1982) it was noted that children suggested using a number of ways of checking whether or not their answers were good ones. The same occurred with the children in the Standard 3 class reported in this paper, and the children went on to specify what they meant by the generalised investigatory strategies. For example, various children suggested consulting reference material which included the library, books, articles, dictionary, spelling books, science world of knowledge and encyclopaedia (although one girl said that encyclopaedia was 'the same as a dictionary really'). Other children suggested consulting people who might know, such as going to a scientist, asking the class teacher or other teachers and students, and asking parents, grandparents, neighbours and friends either face to face or by

telephoning them or writing to them. It was interesting to note that one boy and one girl considered that asking their parents was nearly the same as asking their teacher because 'you'll probably still get the same thing'. It was also interesting to note that several children extended the consultation of people into a survey of the teachers at the school. Several children proposed other activities to check on their answers. These included observations, field study and 'experimentation'. An example of observation was the suggestion by one girl to look to see if animals have seeds inside them:

> "What about if you sort of got an animal, you know, a dead one already, you know, frequently (she means 'recently') died."

An example of a field study proposal was that by the children interested in the money tree question. One girl asked the teacher,

> "When we start doing our exploring and all that, would we be able to go and look at plants, like round the school and that?"

A number of groups decided to carry out an 'experiment' to test whether or not a seed could be grown on the moon by simulating moon conditions as they understood them.

(e) Some of the children's ideas were consistent with a scientific viewpoint, some were not, and others would require further investigation to determine their status:

Ideas which children held with respect to various phenomena emerged during discussions as they worked in their small groups. Some of these ideas would be acceptable to scientists and may indicate, as Oakes (1969) has suggested, that children can, and may be eager to, learn the scientific explanations of many natural phenomena. For example, two boys had a reason for thinking that it does not rain on the moon.

Girl: Does it rain up on the moon though?
1st boy: No, because it hasn't got any clouds.
2nd boy: No clouds
1st boy: Because there's
2nd boy: It's (cloud) just around the world, the earth

Another example which also related to the moon was one boy's idea that the moon lacked oxygen.

"We wanted to know if there is oxygen on the moon. I don't think there is."

A further example was an idea that a boy and a girl had regarding the relationship between a seed and an egg. This emerged during a conversation with the observer and it appeared that the children recognised an equivalence between the two.

Girl: (talking about an ant's egg which she said she had seen a queen ant lay) The egg is a sort of a seed, but it (the seed) could be inside the egg.

Boy: Yeah, because it's like a, when women have babies the baby is kind of a little seed and it grows inside your body and when it's about, a little baby it comes out and then it starts growing; so it grows inside.

Some of the ideas expressed by the children would not find favour with scientists. The children's idea that the moon lacks gravity and that it is very cold because the sun doesn't shine on it are examples. Another example was one boy's idea that the moon does not receive direct sunlight.

"Sometimes when the sun reflects on the earth it can reflect back onto the um, moon and sometimes the moon has a wee bit of light."

A further example which scientists would find difficult to accept was the idea expressed by several children that scientists can solve any problem. This idea came through when children were considering the question: "Will seeds ever grow on the moon?" Children's answers included,

"Yep, chemists will come up with something. There's nothing impossible these days."

It would be impossible others thought,

"Unless you're a scientist." or

"Unless you were a very good scientist about the moon."

Some of the things that the children said or asked could well be explored further with them to find out what their understandings were in respect of these aspects. For example, one girl asked,

"If a seed dies, if you look after it, do you know if it will come alive?"

One could infer from this that the girl thought that seeds are living things but experience suggests that the logic in the form of words used by children at this age level doesn't necessarily reflect the logic of

their thinking. It would be worthwhile investigating whether children think that seeds are living things or not (provided one knew what the children understood 'living' to mean). It is possible that they may regard green (immature) seeds as living but brown (mature) seeds as dead. This possiblility is suggested by a conversation that the observer had with a boy and a girl who had planted a 'catkin' of green silver birch seeds and a 'catkin' of brown silver birch seeds in some soil in a jar. When the observer asked how the children would know, if one plant came up, whether it was from a green seed or brown seed the girl replied that they would know if it came from the green seed,

> "Because it will sort of be a bit younger."

She dug her finger into the soil and said, as she unearthed one of the 'catkins',

> "There's the green one; that sort of comes up green, and the brown one is somewhere."

Whether or not the two children thought that the brown one would grow at all or, if it did, whether or not it would sort of be a bit older and perhaps brown can only be speculated.

Other ideas of the children that could be further investigated are those of 'dirt' and 'air'. At one point in a discussion a boy said that there was no 'dirt' on the moon but quite a lot of rock. What he understood by 'dirt' (or 'soil') would be interesting to find out. During another discussion a boy, speaking about 'air', said that he knew that we give the trees 'carbon dioxide and they give us oxygen'.

> "Because um, we give them carbon dioxide and that makes them kind of, that's their breathing. We breathe out hot air and um, we give them, they give us oxygen..."

What the children's actual understanding of 'air' is would also be worthy of investigation, and why so many children considered that the plants needed oxygen to survive, rather than carbon dioxide, is interesting.

3. Children's responses to the alternative teaching approach

The children's comments and written evaluations of the approach reflected many positive reactions. In general, the children seemed to regard the work as more relevant because it was based on what they wanted to learn rather than what the teacher wanted them to find out. One child expressed appreciation of the work being based on their questions thus:

"We asked the questions that we wanted to know the answers to."

The children also enjoyed listening to, and considering, the ideas put forward by their peers,

"It is interesting to see what other people think that seeds grow from and that."

"We came up with some queer things."

Other positive comments related to the opportunities to use resource material and equipment, to the opportunity to choose their own investigation methods, and to the support they derived from working in groups. The fact that less writing was involved was appreciated as well.

The children's positive response to the approach was also evidenced by the high degree of interest which was sustained throughout the study. The children displayed a desire to continue their investigations outside school time and many were keen to continue them after the study had ended. Several long-term growing experiments conducted by the children meant that interest in the study was sustained for some after it had been completed.

There were also a few negative comments but these all stemmed from breakdowns in group co-operation. For example, there was some reported conflict within groups when one member wanted to take the study in one direction and the remaining children wanted to go in another. Initially, one or two groups had difficulty deciding who should record the groups' ideas, and by the end of the first lesson the teacher found one girl who said that she preferred to work by herself instead of in a group.

"I don't like in the group. I like doing it by myself."

FEATURES OF THE TEACHER'S EXPERIENCE USING THE ALTERNATIVE SCIENCE TEACHING APPROACH

1. Initial thoughts and feelings

From its outset this approach was quite different from other methods which this teacher had employed and for this reason it was approached with mixed feelings.

Formal planning was reduced to a minimum. Although the teacher had certain broad aims in mind, specific objectives for the unit were largely formulated from the children's questions. Likewise, learning activities were largely generated by the children themselves. For this reason the teacher embarked on the study without firm ideas of how the study would proceed. Each group's and each individual's activities were different and the teacher found it necessary to adopt a fairly flexible approach. It was essential for the teacher to be led by the children and their interests rather than attempt to foist her own ideas of appropriate activities and learning outcomes on them. It was also essential for the teacher to recognise teachable moments when they arose and to capitalise on these.

Other methods of teaching (both science and other curriculum areas) tend to be reliant upon specific learning outcomes and set learning activities and, initially, it was difficult for the teacher to overcome a feeling of 'panic' as each individual pursued his or her own objectives. However, this feeling abated as the teacher became more comfortable with the approach and came to realise the value of this type of learning.

2. Perceived difficulties

The approach was not without difficulties. Because the children were carrying out many and varied investigations into seeds there was a great demand for resources, especially books. The teacher provided as many resources as possible but many of the children found that these resources were inappropriate in terms of reading difficulty and content. The teacher found that there was a shortage of resources which children could use independent of an adult at this level. The teacher considered that before using this approach it would be essential to gather together as many appropriate resources as possible. The availability of such resources may depend on the topic.

A second difficulty encountered by the teacher was the practical one of spreading her attention around each group so that the studies could continue in a successful manner. She recognised that for the approach to function effectively the children must receive adequate teacher guidance and unless the teacher is able to provide this, valuable learning

experiences could be lost. She further realised that a good working atmosphere was essential and that the teacher must be prepared to devote all her time to the children. Good control was also vital.

Finally, a difficulty which may, or may not, apply to other classes was that of group relationships. As the study proceeded many children found there were other avenues they wished to pursue and their attempts to diverge, as well as the large number of ideas being generated, caused a strain in relationships in some groups. The teacher found it necessary to allow those individuals who wished to branch out on their own to do so. This preserved harmonious group relations and enabled the children to concentrate on their investigations rather than be distracted by problems within their group.

3. Perceived advantages of the approach

Despite the apparent difficulties associated with the new approach, the advantages were such that the teacher felt that the method was a very worthwhile one. She is fully prepared to use it again in her classroom. A major advantage of the approach was that it was directed totally towards the needs and interests of the children. The children were engaged in answering their own questions and in finding out what they felt they wanted and needed to know. For this reason, the danger of formulating inappropriate objectives was greatly lessened. The children themselves formed the objectives and did so according to what they saw as their needs.

This direction towards the children's needs leads on to the second major advantage of the approach which is the positive attitude towards science that it fostered. It appeared to generate a high level of interest among the children. Because the children were answering their own questions and pursuing their own interests they saw the study as being relevant to their daily lives. They learned the scientific concepts which were meaningful to them and were not required to grapple with concepts with which they were not yet able to cope. Thus science became meaningful and appropriate to them and a positive attitude towards the subject was nurtured.

A high degree of interest appears to have been maintained for several reasons. The fact that the children were answering their own questions and saw relevance in what they are doing helped to support the interest factor. Secondly, the approach was flexible in its use of a variety of resources and research procedures. The children were expected to use equipment, books, surveys and such like to answer their questions. This relatively unrestricted availability of resources and equipment meant that the children were free to learn how to use these in an appropriate manner. This in turn helped to maintain a high degree of interest.

The flexibility of the investigation procedures employed by the children also lead to advantages in terms of the children's skills development. As the children engaged in their inquiries they used many skills in a meaningful way. In general, each group's investigations involved the use of one or two particular skills, with other skills branching out from these. Group sharing sessions also meant that the children were put into contact with a wide cross section of skills.

Finally, a major advantage of the approach from the teacher's point of view was the great insight that it provided into children's ideas and views of the world about them. From the initial questioning it became apparent exactly what the children regarded as the important and interesting ideas about the topic. These initial questions also reflected, to a certain extent, the children's prior knowledge of the topic. As the investigations proceeded and the teacher talked with the children and observed how they coped with problems, she gained many new and interesting understandings about how the children perceived the things around them.

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ACKNOWLEDGEMENTS

We gratefully acknowledge both the support for this study offered by Mr Colin McCormack, Principal, Glenview Primary School, and the contribution made by the children who participated.

We also extend sincere thanks to Beverly Bell for her sensitive assistance as resource biologist.

Comments by Roger Osborne on an earlier draft of this paper were greatly appreciated.

Appendix 1

PROPOSED PRIMARY SCIENCE TEACHING MODEL

Step 1: CHILDREN IN INTERESTING SITUATION

A situation that stimulates the children to ask questions related to a science topic.

Step 2: CHILDREN'S QUESTIONS ON THE TOPIC

These could be publicly recorded e.g. on the board.

Step 3: CHILDREN'S SUGGESTED ANSWERS TO A QUESTION

These could be written on paper by the children either individually or in groups and if desired then also listed on the board.

Step 4: CHILDREN'S RESEARCH PROPOSALS

At this step the children either individually or in groups write a research proposal outlining:

(a) the question/answer they are going to check on
(b) how they are going to check on it
(c) where they are going to check on it
(d) how long they estimate they will take
(e) what equipment they will need

Teacher approval will be necessary before children embark on Step 5. (A teacher may decide to accept some proposals that are doomed to failure but from which children will learn something useful.)

Step 5: CHILDREN'S RESEARCH ACTIVITY

The children conduct an inquiry on <u>their</u> problem using <u>their</u> suggested activity. This may be

(a) observation or 'experiment'
(b) consulting books
(c) consulting knowledgeable people

Step 6: CHILDREN'S RESEARCH REPORT AND PEER COMMENTS

The children report their findings to the rest of the class. The other children, with teacher guidance, comment on

(a) whether or not the group or individual had really found out what they were trying to find out
(b) possible alternative explanations
(c) other studies that might follow

Appendix 2

CHILDREN'S QUESTIONS ABOUT 'SEEDS' (Taken by class teacher)

1. Which came first, the seed or the tree?
2. Why does that one have prickles on it?
   (Why are some seeds prickly?)
3. How are seeds made?
4. Why do little seeds grow into big trees?
5. Why are some seeds slippery?
6. Why are they all in different shapes?
7. Do all plants and trees contain seeds?
8. Where did the first seed or tree come from?
9. Why are seeds hard?
10. Do all seeds grow into vegetables?
11. Why are some seeds poisonous?
12. Why are seeds on trees?
13. Why have pine cones got those flat things sticking out?
14. Is there a popular tree in New Zealand?
15. Will trees and seeds ever run out?
16. What is the biggest tree in the world?
17. How would a tree become extinct?
18. How do seeds travel?
19. Why do seeds grow?
20. When would we ever be able to eat leaves on a tree?
21. What does a seed contain?
22. Will there ever be a money tree?
23. How do seeds die?
24. Where do seeds go when they're dead?
25. Does it help if you talk to your seeds to make them grow?
26. Why do seeds cost money?
27. Why do plants grow with money? (I saw on television if you put money in the ground a plant will grow up.)
28. Why do ferns have seeds? Where do they keep them?
29. Have seeds ever flown?
30. Where does oxygen come off a tree?
31. Will seeds ever grow on the moon?
32. Do animals have seeds inside them? (Question asked by Mr Biddulph and recorded because some children were interested in it.)

Appendix 3

CHILDREN'S QUESTION CHOICES AND POSSIBLE ANSWERS

Bruce, Garrick, Vivienne, Kate:

"Will seeds ever grow on the moon?"

1. It might be possible that a plant could live on the moon but I don't think so. If a plant went on the moon I think it would die from the coldness and it would die from oxygen.

Gavin, Karam:

"Will seeds ever grow on the moon?"

1. Karam and I think that plants will grow on the moon. They have already tried experiments with carbon dioxide.

Jason, Ben, Chris, Nathan:

"Will seeds ever grow on the moon?"

1. If men went to space with seeds they will grow.
2. If lots of wind blow seeds into space.
3. If seeds grow on the moon it will be time.
4. Cut the seed open and put a hunk of steel in it.

Mark, John:

"Will seeds ever grow on the moon?"

1. Plants will because they could make a huge glass house and they could put dirt in it and grow plants in it.

Richard, Alison, Belinda:

"Do animals have seeds inside them?"

1. Yes, they do.
2. Some animals don't.
3. Apes do, eat bananas.
4. We sort of grow from seeds.
5. Fish don't have seeds.
6. The queen bee and ant lay hundreds of eggs.

Todd, Wayne, Melanie, Fiona:

"Do animals have seeds inside them?"

1. Animals do have seeds inside them.
2. Animals have grass seeds in them.
3. Animals grow by seeds.

Donna, Lisa, Vicky, Jenny:

"Will there ever be a money tree?"

1. No, because it is impossible.
2. We never know.
3. Money never grows on trees. It's only a saying.
4. How would you get a money seed?

Wendy, Emma, Caroline, Michelle:

"What does a seed contain?"

1. Contains smaller seeds.
2. Powdery substance (our answer)
3. Sawdusty substance (proper answer)

It's shell broke when we opened it (bean)

Tracey, Lisa:

"Will trees and seeds ever run out?"

1. No, because there is nothing to make them run out in the world, but if they ever did run out we wouldn't have any oxygen and we wouldn't be able to live.

Appendix 4

CHILDREN'S FURTHER QUESTIONS WHEN RESOURCE BIOLOGIST PRESENT

1. Well, if a seed has a thick layer on top of it so nothing can get into it, how would the seed kind of burst out?

2. If a seed's in some real hard ground, and how will it get out if the sun was getting to it, and it was in clay; how would it get out, you know, if it was all dry, all the clay was dry?

3. If a seed's got a really thick skin on it, is that because a lot of animals like to eat it, or is it just so when it drops onto the ground it'll be...?

4. If the seed dies, if you look after it, do you know if it will come alive again?

5. If you just put seeds on the window sill would it just, would it grow by itself?

6. Well, if you had a seed and you put it in water, and you keep watching it and watching it all day and night, could you actually see it grow up?

7. If you've got a little seed and it's got a little bit of water in it, got some water, and you looked after it very well, would it come, would the rot go away?

8. Is the embryo seed the, sort of part of it?

9. Do all plants have seeds in them?

10. Which came first, the seed or the tree?

11. In a pine cone, what are those little, those things sticking out?

12. If you had a seed and it didn't (unclear what was said here) out of the way, what would happen if, would it fade away, something like that?

13. Why are seeds so hard; is it just to protect theirselves?

14. Why do they have that skin on?

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